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ВЛИЯНИЕ Zr, Sc, Ti, B Fe И Ni НА МИКРОСТРУКТУРУ СПЛАВА АА7075 ПРИ ЛАЗЕРНОЙ ОБРАБОТКЕ

В настоящей работе исследован высокопрочный сплав АА7075, дополнительно легированный 0,3%Sc+0,5%Zr, 1%Ti+0,2%B и 1%Fe+1%Ni для повышения сопротивляемости сплава образованию горячих трещин и однородности структуры.

Ключевые слова: Al–Zn–Mg–Cu, переходные металлы, модифицирование, микроструктура, лазерное плавление, гомогенизационный отжиг

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INFLUENCE OF Zr, Sc, Ti, B, Fe AND Ni ON THE MICROSTRUCTURE OF AA7075 ALLOY DURING LASER PROCESSING

In the present work the wrought aluminium alloy AA7075 modified with 0,3%Sc+ 0,5%Zr, 1%Ti+0,2 %B and 1%Fe+1%Ni to refine and uniform the grain structure, to decrease the effective solidification range to decrease the hot crack formation during rapid solidification after laser processing was studied.

Keywords: Al–Zn–Mg–Cu, transition elements, modification, microstructure, laser melting, homogenization annealing

Ultra-high-strength 7xxx alloys are generally utilized in transportation, aerospace applications, corrosion resistance applications [1–2]. The disadvantages of these alloys are due to them containing several alloying elements; the received solid structure shows differences in chemical composition from the center of the dendrite to the edges [3]. Alloying elements and contaminations form coarse eutectic structures and arrange in the dendrite and interdendritic boundaries during the solidification process, which lead to high crack sensitivity and bad castability. The addition of minor Sc, Zr, Ti and B elements enhances the metallurgical state of the 7xxx series [4] and is most commonly used to make the lid of the aluminium can. With a view to the possible future development of a micro-macro model to describe the casting of this alloy, the effect of grain refinement on the microsegregation of magnesium in industrial rolling ingots of AA5182 has been investigated at three different depths beneath the edge of the ingot (and hence three different cooling rates.

The investigated alloys after casting were the standard alloy Al–6,9Zn–2,2Mg–1,4Cu–0,3Mn–0,3Cr. the microstructure of the standard alloy was coarse grains with average size 272 ± 20 μm. And the modified alloys by adding 0,3 %Sc+0,5%Zr and 1%Ti+0,2%B, the grain size was 11 ± 2 μm and 23 ± 2 μm respectively. And by adding 1%Fe+1%Ni a coarse structure with average size 316 ± 15 μm was obtained with the formation of extremely unfavorable morphology, close to a needle-like structure. Homogenization annealing 460 °C for 3 h was done to homogenize the grain structure and eliminate the formation of non-equilibrium eutectic phases [5].

The microstructures after laser melting 300 V, duration 14 ms and Argon as shielding gas of the modified alloys and homogenized annealing can be concluded. In AA7075-standard, the structure was divided into three zones: Base Metal (BM), Heat Affected Zone (HAZ), and Laser Melted Zone (LMZ). The HAZ has a eutectic structure with columnar shape which is almost the same as the BM but with slightly more elongated shape, and these grains have a random crystal orientation. During solidification the grains in the LMZ start to grow from these randomly oriented grains. Non-dendritic equiaxed grains appeared along the fusion line in the LMZ with direction parallel to the opposite direction of the laser heat flow. At the center of the LMZ, there is the appearance of a fine zone in which the structure changed from elongated to fine equiaxed grains.

Figure 1 shows the microstructure of studied alloys after laser melting. Effect of the presence Sc + Zr and Ti + B in the laser processed samples act as a modifying to this alloy. Fine and uniform structures were observed during rapid solidification. This grain refinement resulted from the presence of primary Al3 (Zr, Sc) and TiB2 particles, which formed during the alloy solidification and became the nuclei for the crystallization of the Al solid solution. In case of alloy with adding Fe + Ni, the coarse structure and eutectic crystal were remelted, causing the formation of eutectic intermetallic phases around the dendrites. Structure formation started from the boundary of the BM to the surface in the opposite direction to the heat flow, but it did not act as a modifying element during solidification.

The Distribution of alloying elements across the LMZ are present on fig. 2.

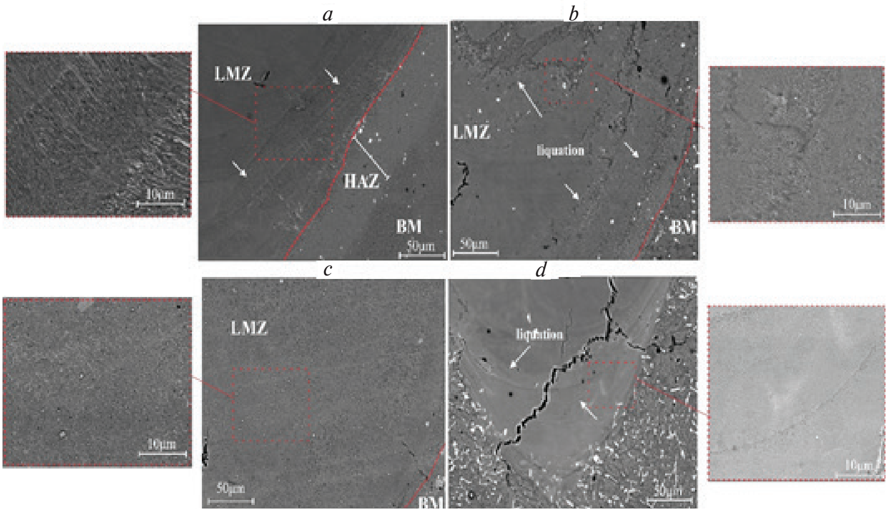

Fig. 1. BM and LMZ of the investigated alloys (*a*) AA7075-standard, (*b*) AA7075-ScZr, (*c*) AA7075-TiB and (*d*) AA7075-FeNi

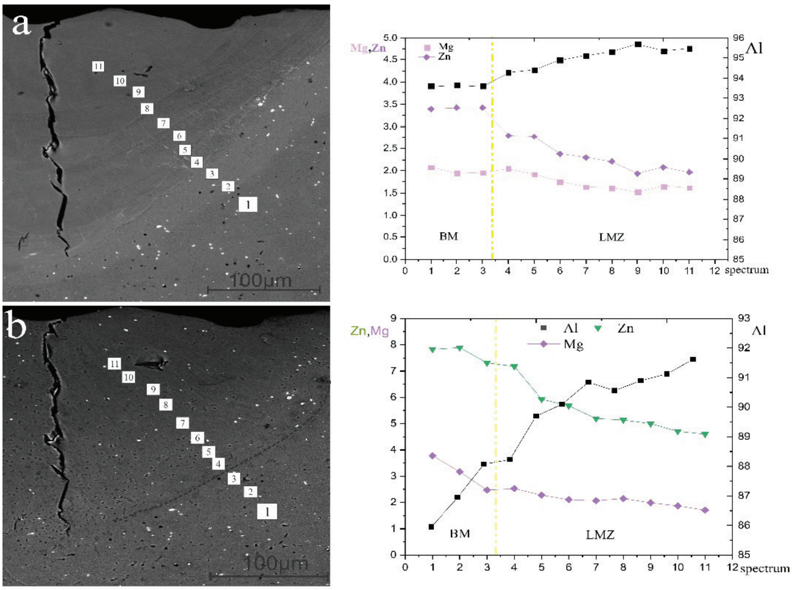

Fig. 2. Distribution of elements for standard alloy

a — after laser proceesing and *b* — after laser processing and annealing at 460 °C for 1 h

As it shown, liquation effect of Zn and Mg was observed in LMZ during laser melting due to the evaporation. Homogenization annealing 460 °C for 1 h post-laser melting was done to let the alloying elements to diffuse and be uniform through all the LMZ as in figure 2b, but this homogenization was affectless on the structure.

Conclusion:

AA7075-Standard alloy observed coarse structure after casting, adding Sc+Zr and Ti+B modified and refined the microstructure with formation of primary Al_3 (Zr, Sc) and TiB_2 particles and adding Fe+Ni didn't act as a modificator.

After laser melting, the microstructure was changed and the grain size decreased significantly after the AA7075-Standard was modified with rare earth elements Sc, Zr, Ti, B, Fe, and Ni. Some equiaxed grains were formed in the region near the boundary of the melted zone; above and below this boundary were the equiaxed grain zone and the heat-affected zone (HAZ), respectively. The best structure after laser melting was in AA7075–TiB and AA7075–ScZr.

Severe liquation effects appeared in AA7075-standard this caused non-uniform elemental distribution on the LMZ, leading to bad properties of the laser-melted area, but after annealing 460 °C for 1h the distribution of elements was slightly uniform through the BM and LMZ.

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